

## SPECTROMETER INCLUDING METASURFACE

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/198,337, filed on Jul. 29, 2015, in the U.S. Patent and Trademark office, and claims priority from Korean Patent Application No. 10-2016-0045802, filed on Apr. 14, 2016, in the Korean Intellectual Property Office, the disclosures of which are incorporated herein by reference in their entireties.

### BACKGROUND

[0002] 1. Field

[0003] Apparatuses consistent with exemplary embodiments relate to a spectrometer including a metasurface.

[0004] 2. Description of the Related Art

[0005] Optical elements for changing transmittance, reflection, polarization, phase, intensity, and paths of incident light are used in various optical devices. The optical elements include a heavy lens, a mirror, etc., and, thus, it is difficult to miniaturize the optical devices including the optical elements. A spectrometer includes an optical element, and this may make the spectrometer big and heavy. Various research into miniaturizing a structure of the spectrometer and improving the performance of the spectrometer has been conducted.

### SUMMARY

[0006] Exemplary embodiments address at least the above problems and/or disadvantages and other disadvantages not described above. Also, the exemplary embodiments are not required to overcome the disadvantages described above, and may not overcome any of the problems described above.

[0007] One or more exemplary embodiments may provide a spectrometer including a metasurface.

[0008] According to an aspect of an exemplary embodiment, a spectrometer includes: a transparent substrate including a first surface and a second surface facing each other; a slit provided on the first surface and through which light to be examined is incident onto the transparent substrate; a spectrum optical system provided on the first surface or the second surface and including at least one metasurface including a plurality of nanostructures that are two-dimensionally arranged and a surrounding structure surrounding the plurality of nanostructures, wherein the at least one metasurface includes a focusing metasurface reflecting and focusing the light incident through the slit, at different angles based on respective wavelengths; and a sensor provided on the first surface or the second surface of the transparent substrate and receiving the light from the spectrum optical system.

[0009] The spectrometer may further include a block layer provided on the transparent substrate and blocking the light from being incident onto areas other than the slit.

[0010] The spectrum optical system may further include a collimating metasurface including a plurality of nanostructures that are two-dimensionally arranged to have a collimating function.

[0011] The collimating metasurface may be located on an optical path between the slit and the focusing metasurface.

[0012] The spectrum optical system may further include a grating metasurface including a plurality of nanostructures that are two-dimensionally arranged to have a chromatic dispersion function.

[0013] The grating metasurface may be located on an optical path between the collimating metasurface and the focusing metasurface.

[0014] The grating metasurface and the sensor may be provided on the first surface, and the collimating metasurface and the focusing metasurface may be provided on the second surface.

[0015] The grating metasurface, the collimating metasurface, the focusing metasurface, and the sensor may be two-dimensionally arranged, on a plan view seen from a direction perpendicular to the first surface.

[0016] The transparent substrate may include side surfaces connecting the first surface and the second surface, and on the plan view seen from the direction perpendicular to the first surface, the collimating metasurface and the grating metasurface may be arranged adjacent to one side surface of the side surfaces, and the focusing metasurface and the sensor may be arranged adjacent to the other side surface facing the surface.

[0017] In the at least one metasurface, a height of each of the plurality of nanostructures, or a longest diameter of a section of the plurality of nanostructures may be less than a wavelength of the light.

[0018] The spectrum optical system may include a grating metasurface, the grating metasurface may include a pattern including a plurality of nanostructures arranged apart from each other in a second direction, and the pattern may be cyclically repeated in a first direction that is perpendicular to the second direction.

[0019] The focusing metasurface may have one or more ring-shaped areas in which diameters of the plurality of nanostructures increase or decrease as the plurality of nanostructures distance from a point on the focusing metasurface.

[0020] The spectrum optical system may further include a split metasurface configured to split the light into first polarization light and second polarization light based on polarization and reflect the split first and second polarization lights based on wavelengths, and the sensor may include a first sensor configured to receive the split first polarization light and a second sensor configured to receive the split second polarization light.

[0021] The focusing metasurface may include a first focusing metasurface configured to focus the first polarization light to the first sensor and a second focusing metasurface configured to focus the second polarization light to the second sensor.

[0022] The split metasurface may include a pattern including a plurality of nanostructures arranged such that each diameter of elements thereof in a first direction increases and then decreases, and the pattern may be cyclically repeated in the first direction and a second direction that is perpendicular to the first direction.

[0023] When  $L$  is a total length of an optical path from the slit to the sensor and  $D$  is a thickness of the transparent substrate,  $L$  and  $D$  may satisfy the following inequality:  $L/D > 3$ .

[0024] The surrounding structure may include at least one among silicon dioxide ( $\text{SiO}_2$ ), glass, and a polymer.

[0025] The transparent substrate may include at least one among  $\text{SiO}_2$ , glass, and a polymer.